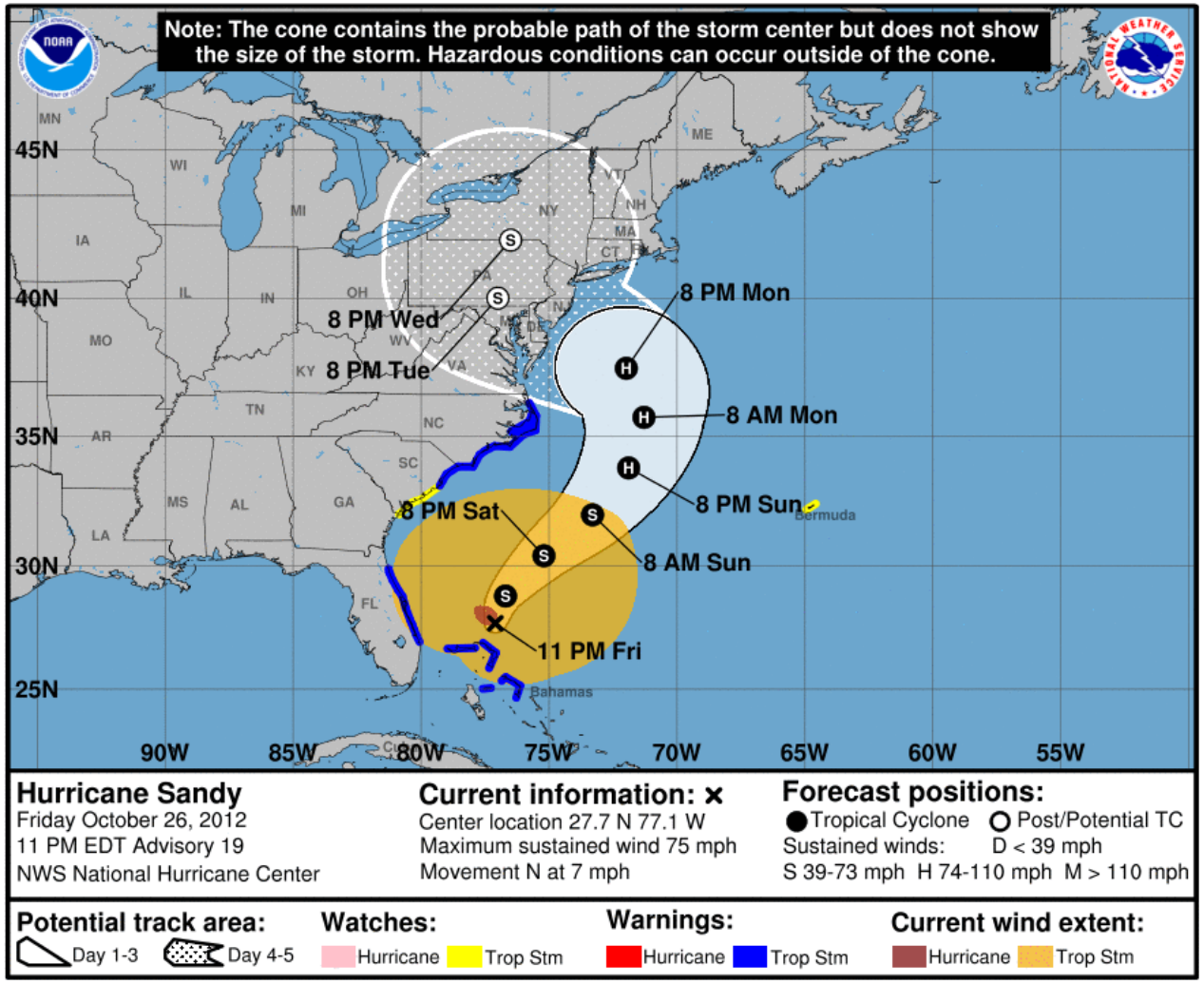
Cone of Uncertainty

Social and Behavioral Science Research

October 16, 2020

ERG



Research Team

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- Dr. Betty Morrow
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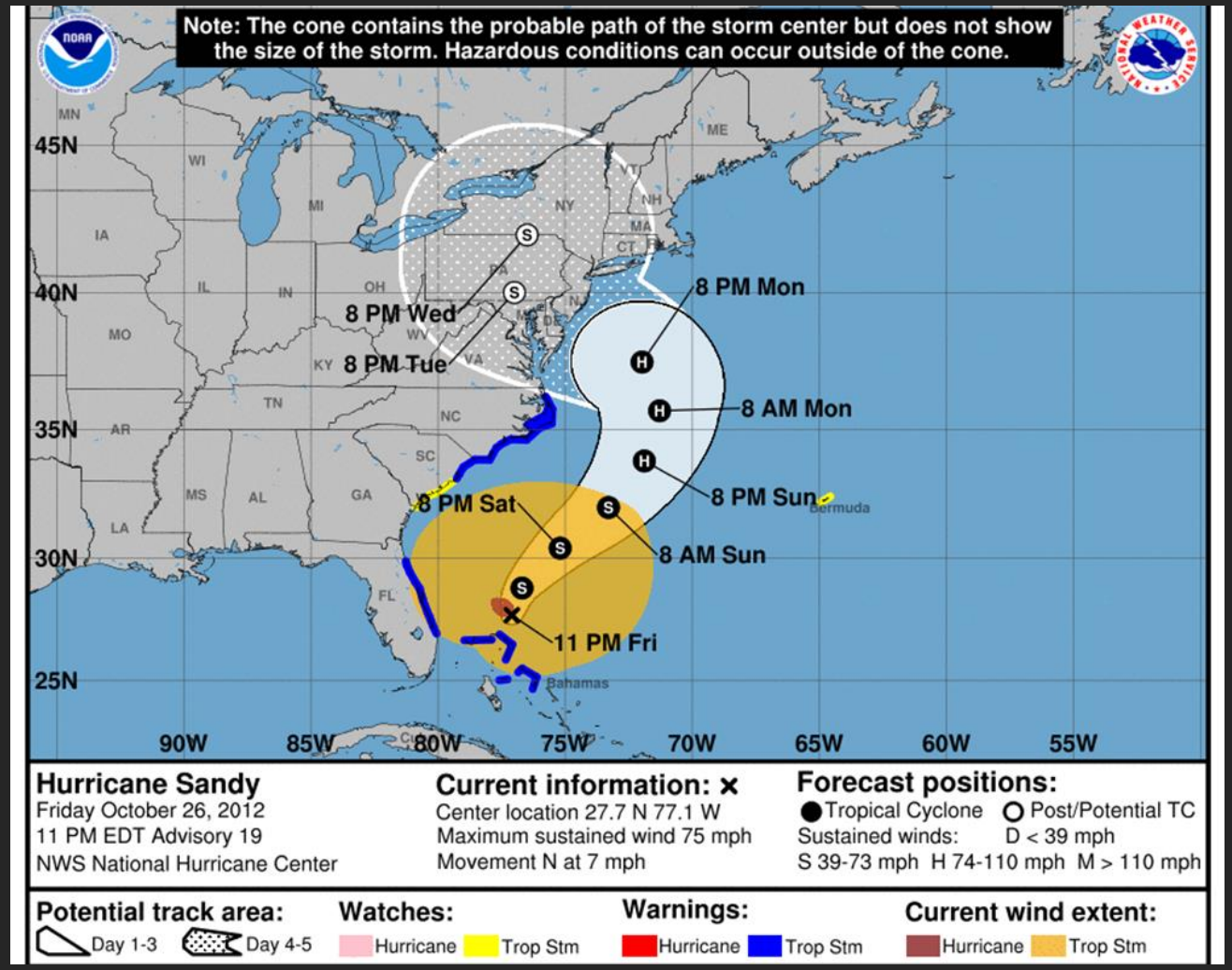
What Is the Cone Graphic?

- Represents the probable track of the center of a tropical cyclone.
- Formed by enclosing the area swept out by a set of circles (not shown) along the forecast track (at 12, 24, 36 hours, etc.).
- The size of each circle is set so that two-thirds of historical official forecast errors over a 5-year sample fall within the circle.



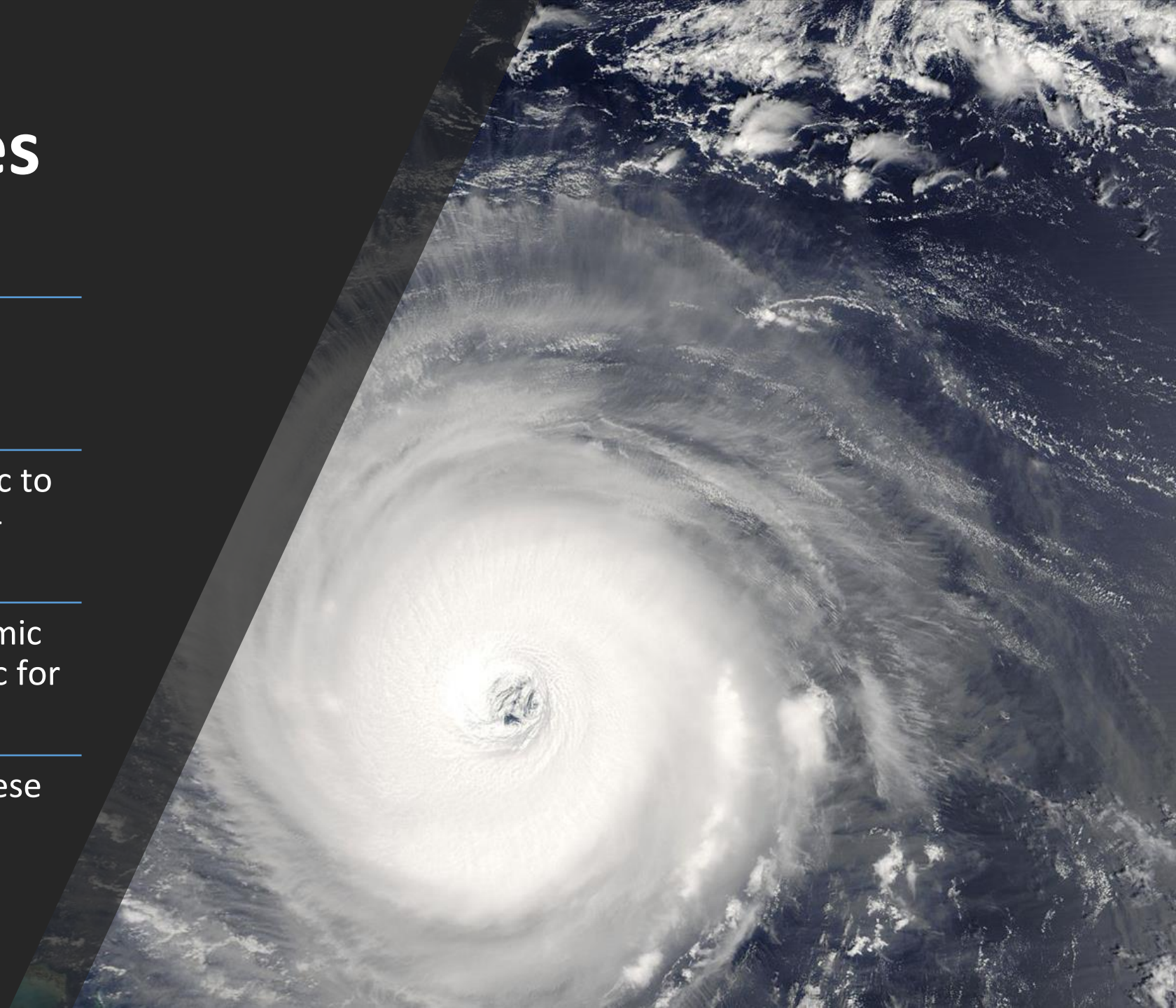
Study Purposes

How do people interpret (or misinterpret) the Cone of Uncertainty graphic?

How integral is the Cone Graphic to international partners' decision-making?

How much do important economic sectors rely on the Cone Graphic for operational decision-making?

Does the Cone Graphic meet these users' and stakeholders' needs?

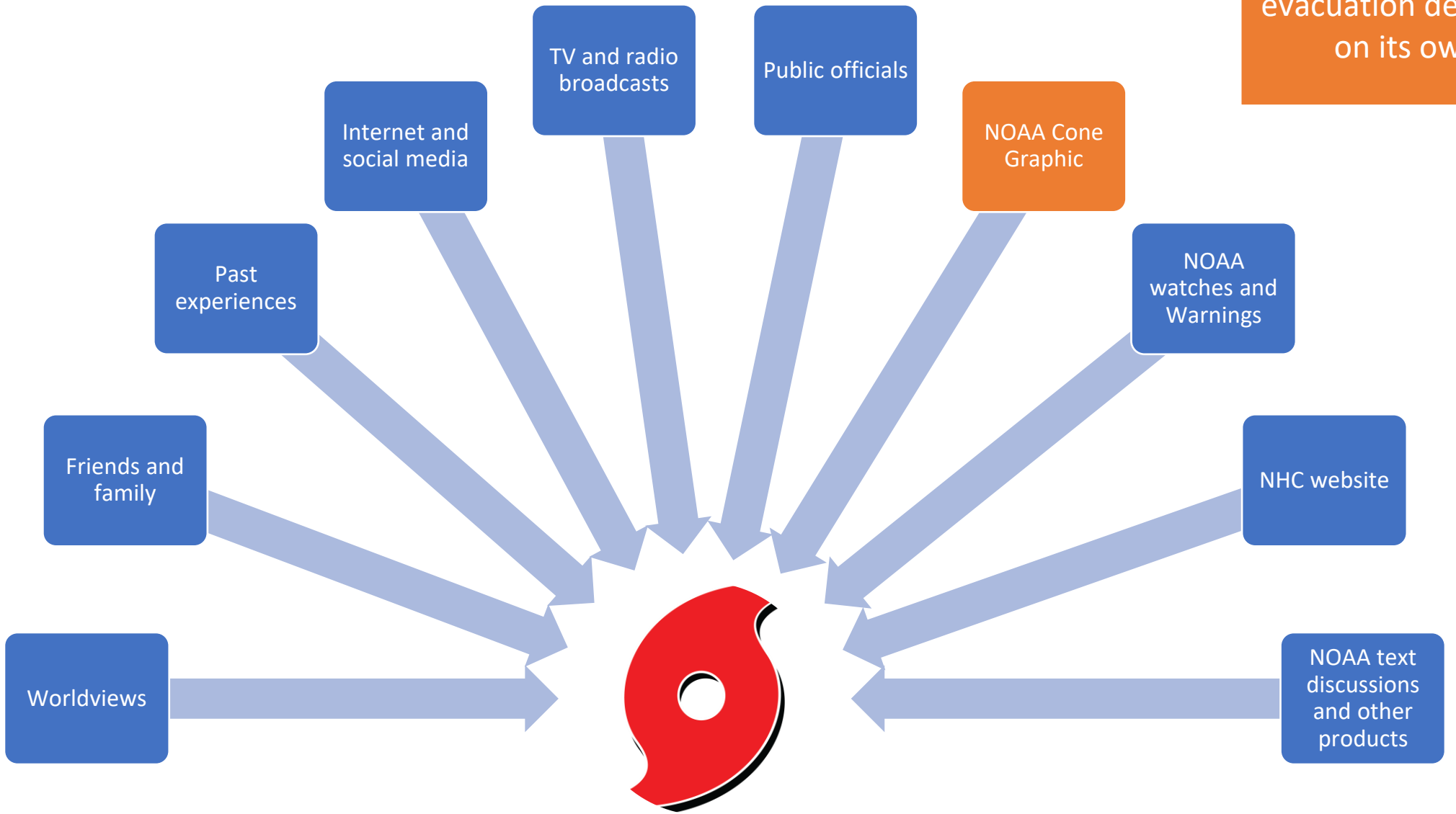


Approach

Approach	Purpose	Study Group	Final Report
Literature review	Understand interpretations of the Cone Graphic, implications for decision-making, and ideas for enhancements.	Members of the public Public officials, emergency managers Broadcasters	April 2019
Interviews	Understand how the Cone Graphic is used in decision-making and whether it serves operational and stakeholder communication needs.	International meteorologists in Bermuda, Canada, Cuba, Jamaica, Mexico, and Netherlands	July 2020
Survey	Understand interpretation, use, and implications for decision-making by lesser-studied but economically significant sectors.	Decision-makers in tourism/recreation, energy/utilities, marine, and transportation sectors	September 2020

Literature Review

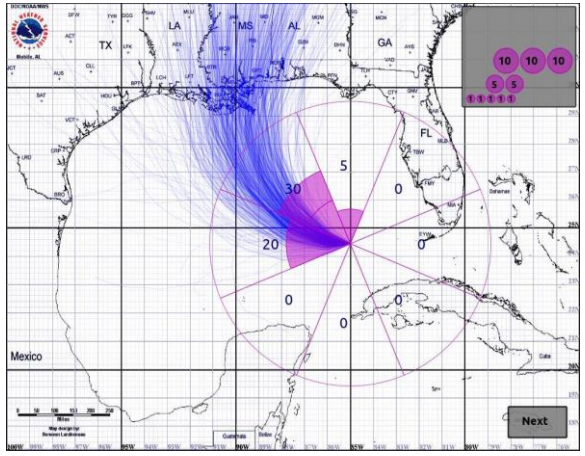
Factors Influencing Public Decision-Making



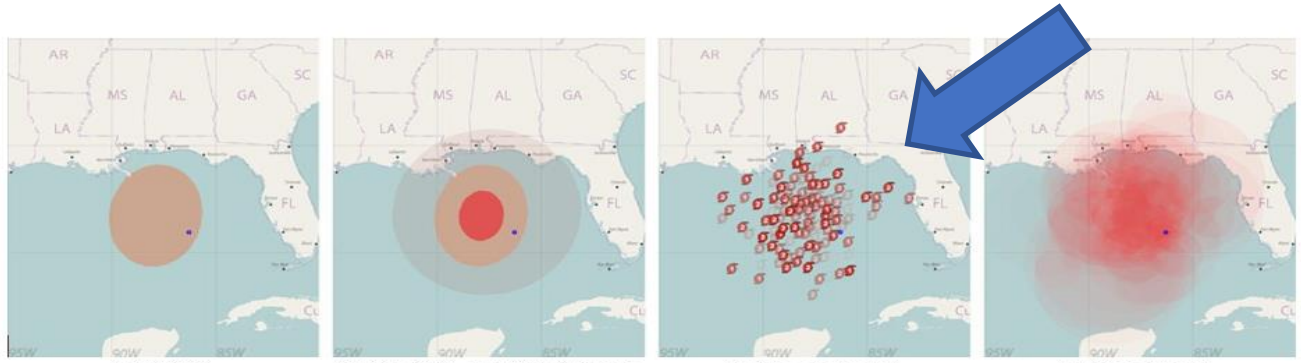
May not influence evacuation decisions on its own

Misunderstanding	Implication
Seeing the cone as an impact visualization	• Believing you are “safe” if located outside of the cone or “doomed” if inside the cone.
Equating the cone to storm size or intensity	• Believing the hurricane is growing in size or strength as it approaches land.
Focusing on the forecast track	• Not recognizing that landfall/impacts could occur at adjacent locations. • Loss of interest in a hurricane when a track shifts away from a person’s location. • Not recognizing that a storm’s present track could change in the future.

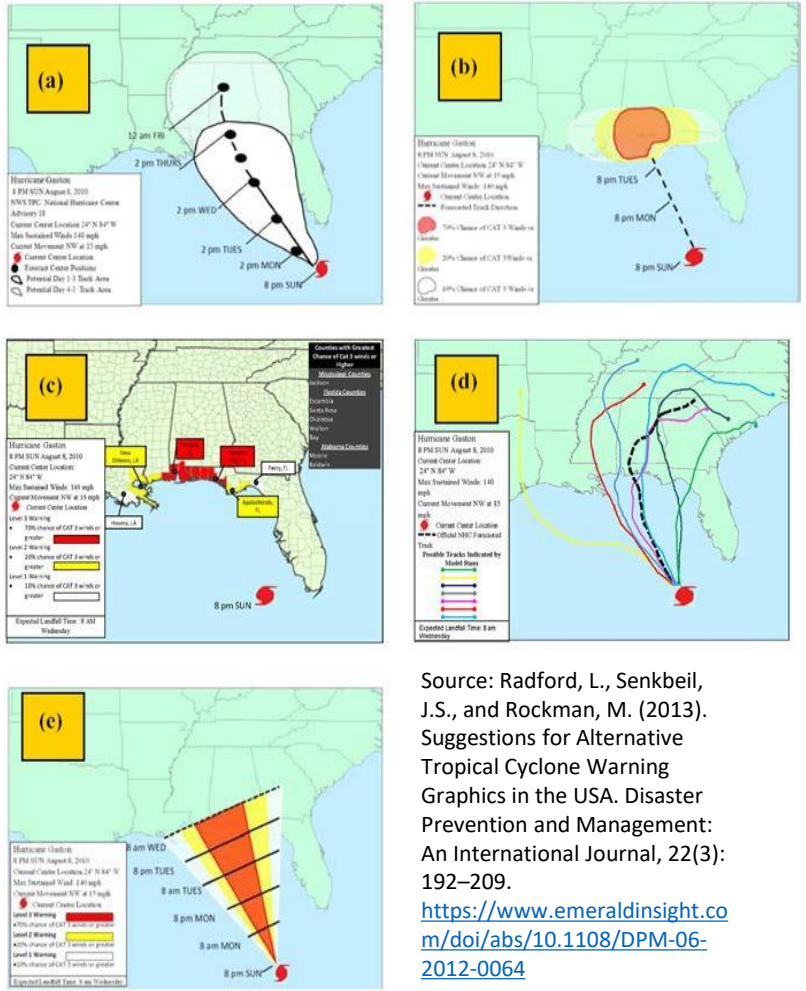
Visualizations



Source: Cox, J., House, D., and Lindell, M. (2013). Visualizing Uncertainty in Predicted Hurricane Tracks. *International Journal for Uncertainty Quantification*, 3(2): 143–156.



Source: Liu, L., Boone, A.P., Ruginski, I.T., Padilla, L., Hegarty, M., Creem-Regehr, S.H., Thompson, W.B., Yuksel, C., and House, D.H. (2017). Uncertainty Visualization by Representative Sampling from Prediction Ensembles. *IEEE Transactions on Visualization and Computer Graphics*, 23(9): 2165–2178. https://doi.org/10.1109/TVCG.2016.2607204



Source: Radford, L., Senkbeil, J.S., and Rockman, M. (2013). Suggestions for Alternative Tropical Cyclone Warning Graphics in the USA. Disaster Prevention and Management: An International Journal, 22(3): 192–209. https://www.emeraldinsight.com/doi/abs/10.1108/DPM-06-2012-0064

Interviews with International Meteorologists

Participants

- Bermuda Weather Service
- Canadian Hurricane Centre
- Cuba National Forecast Center of the Institute of Meteorology
- Meteorological Service of Jamaica, Weather Branch
- National Meteorological Service of Mexico
- Royal Netherlands Meteorological Institute (serving Bonaire, Saba, and St. Eustatius)

Strengths and Weaknesses

Positives

- Very familiar to audiences
- Provides important first-view, possible track movements, high-level overview
- Can help people assess confidence as lead times get shorter

Negatives

- Can be over-reliance on graphic for decision-making
- Does not provide information on hazards
- Is not well understood by the public
- Does not explain impacts

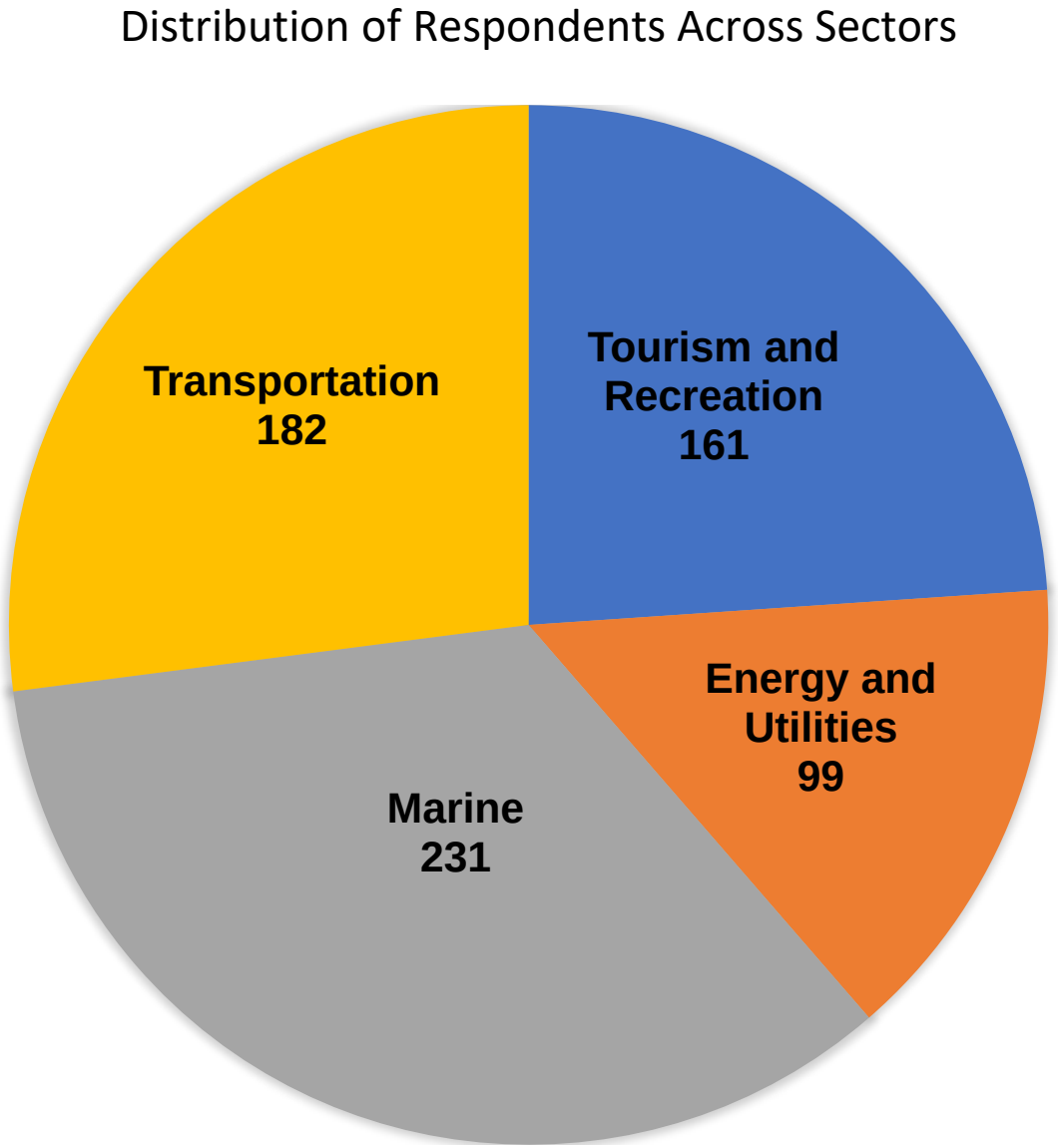
Ideas for Enhancements

- Multiple layers of information
- Interactive
- Overlay with satellite imagery
- Provide context
- Dynamic cone produced with real-time ensemble data

Web-Based Sector Survey

Survey Respondents

- 491 respondents
- Pacific and Atlantic regions
- 75% were either the primary decision-maker or part of top decision-makers
- 89% had 11+ years of experience



Key Topics Assessed

General

- Prior storm experience
- Forecast information sources
- Forecast parameters
- Use of NWS products for decision-making
- Familiarity with and reliance on ensemble displays

Cone Graphic

- Familiarity with the graphic
- Assessment of features
- Communication effectiveness
- Interpretation of graphic
- Importance to decision-making

Survey Findings: Familiarity and Importance

- Across all sectors, respondents are very familiar with the Cone Graphic
- It is important to their activities, operations, and decision-making

Survey Findings: Misunderstandings

- Depicts areas that could experience strong winds (all sectors, esp. tourism and recreation)
- Indicates when strong winds are likely to arrive (all sectors)
- Covers all possible tracks for storm (all sectors, esp. tourism and recreation)

The tourism and recreation sector also generally said they find the graphic effective and easy to understand

AND

Rated the graphic as important to their decision-making

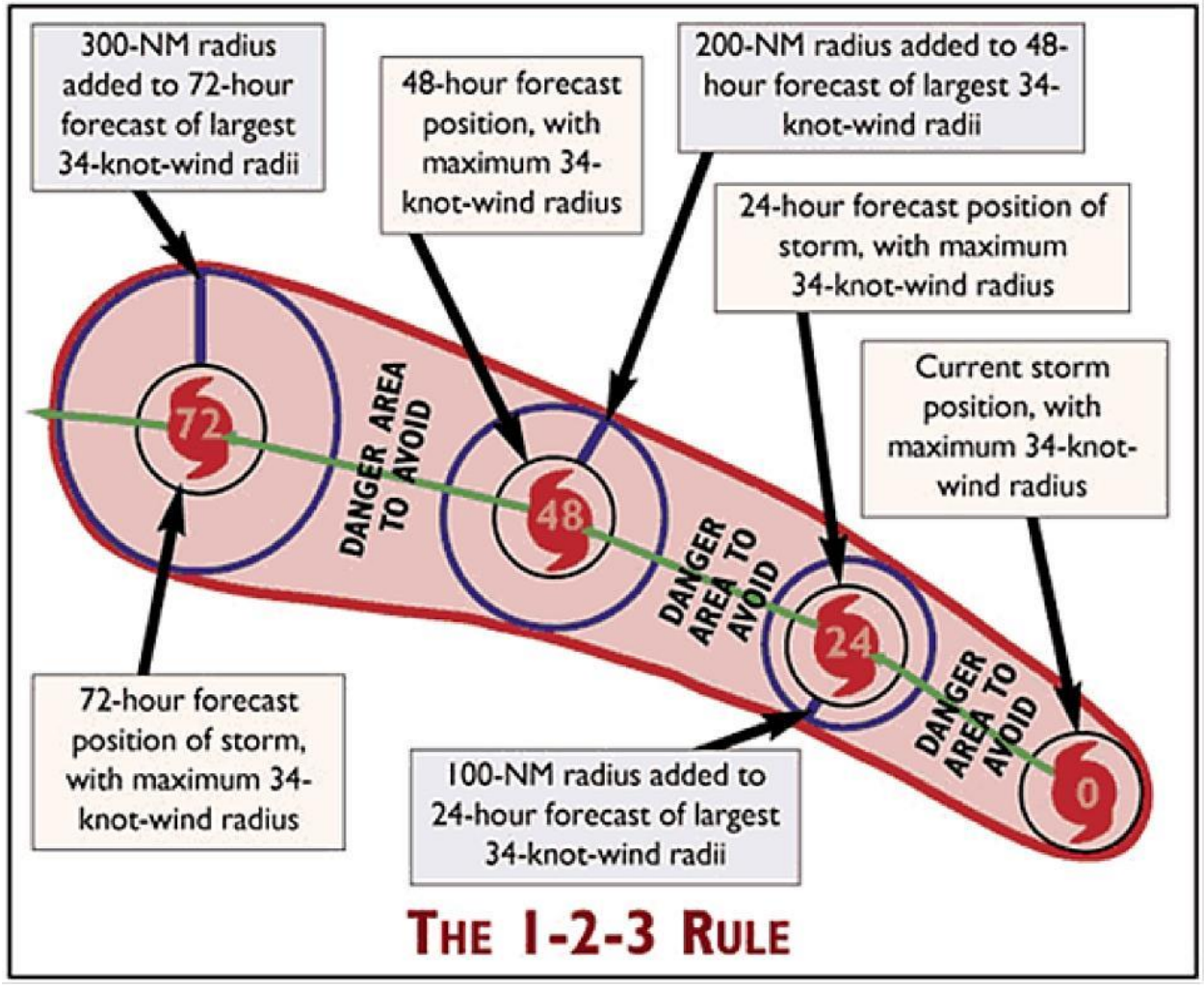
Survey Findings: Respondents with Prior Storm Experience

- More likely to understand that impacts can occur outside of cone boundary

- Less likely to believe that the graphic shows where storm is likely to go
- Less likely to believe the center line and cone feature are effective

Survey Findings: Marine Sector

- Rated the Cone Graphic as important to its decision-making
- Some aspects of the Cone Graphic are hard to understand (legend in particular)
- Some prefer Mariner 1-2-3 Rule graphic



Survey Findings: Energy and Utilities

- Helps them decide whether and when to prepare
- Provides **all** the information needed for preparation decisions

Survey Findings: Transportation

- Less likely to understand the cone size depends on level of accuracy in previous track forecasts

Key Overarching Findings

Familiar

The Cone Graphic is very familiar to all audiences, from members of the public to experienced professionals in the sectors studied.

Valuable

It is valuable (even critical) to decision-making for international forecasters and the professionals in the sectors studied.

Misinterpreted

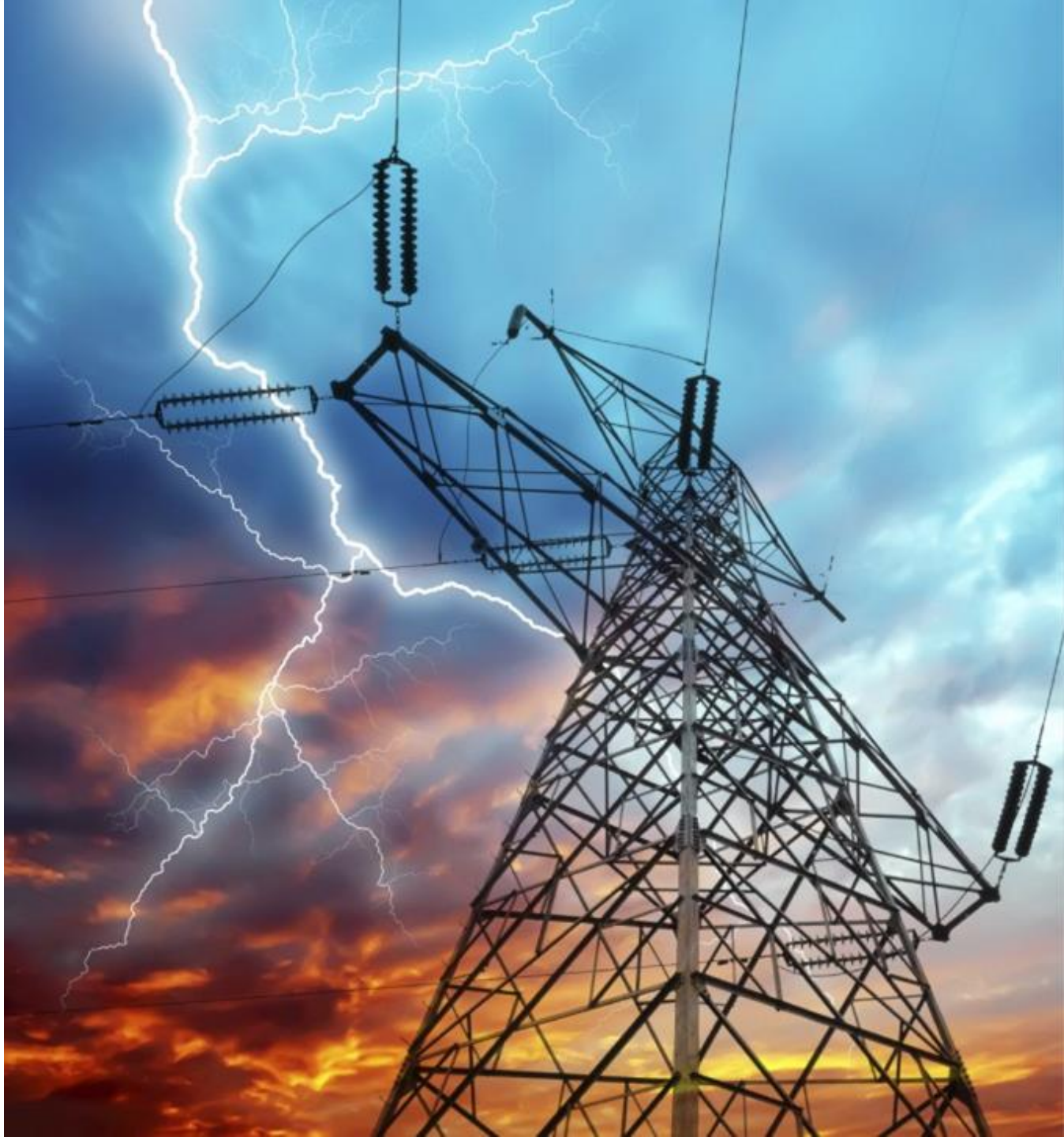
Aspects of the Cone Graphic are misunderstood or misinterpreted, even by professionals in the sectors studied.

One of Many Pieces of Information

While the Cone Graphic is not the only piece of information that people use to make preparedness decisions…

Some Over-Reliance?

… there may be some over-reliance on the Cone Graphic by some professional entities.



The Paradox

The current Cone Graphic might have too much information to process cognitively...

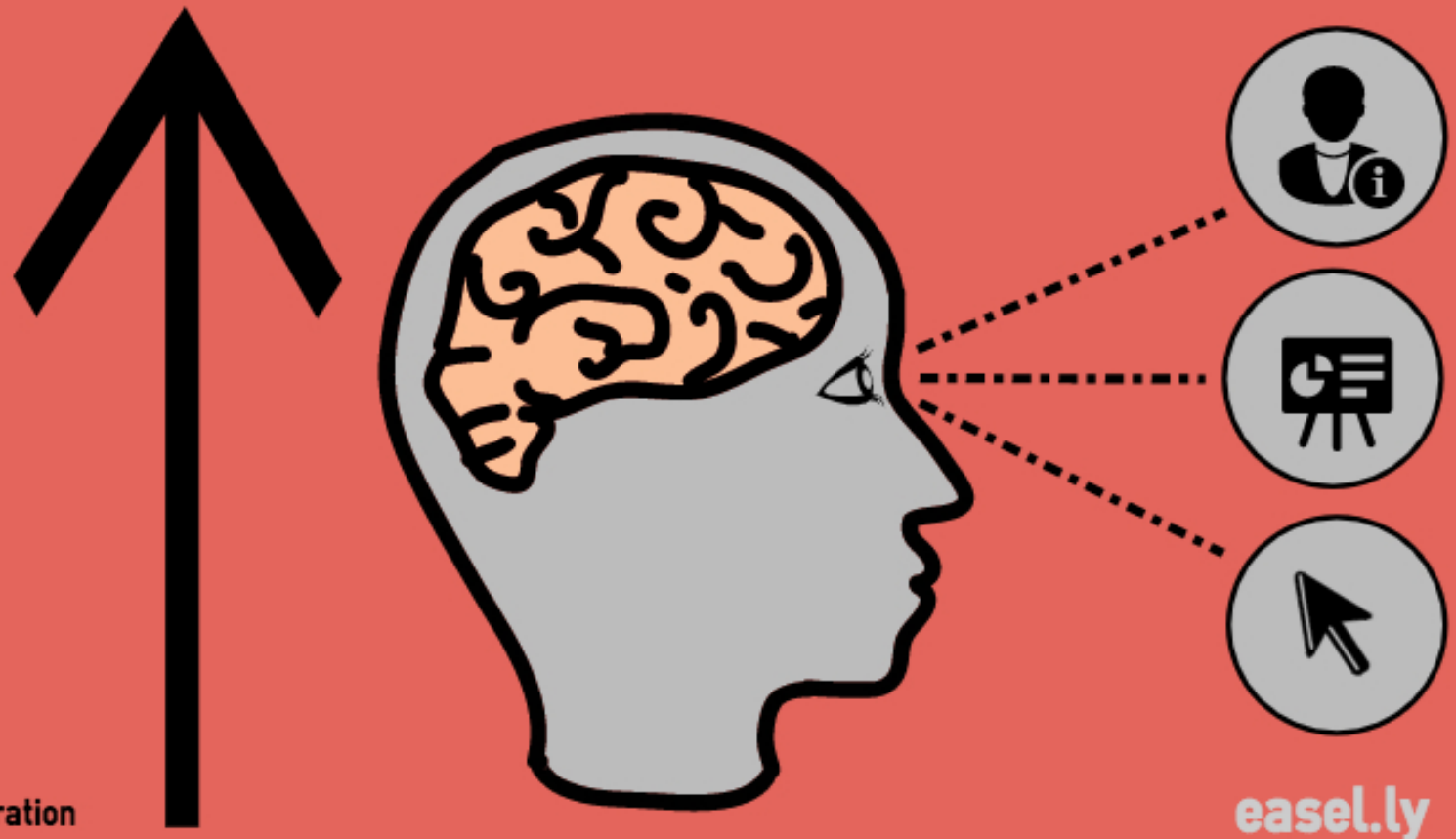
And it yet it doesn't have *all* the information people want.

Looking Ahead

HUMANS ARE VISUAL CREATURES

VISUALS IMPROVE LEARNING BY UP TO 400%

Source: Polishing Your Presentation, 3M Corporation



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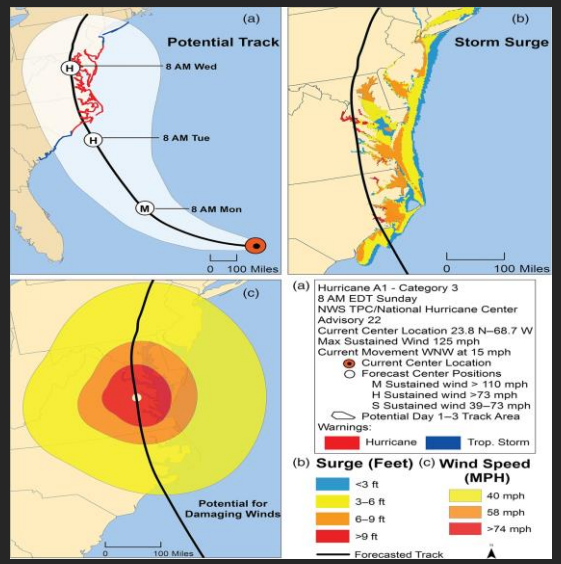
Can One Graphic Do It All?

Possible Approaches

- Education
- Cosmetic changes or digital enhancements
- Combination or supplemental graphics
- New visualization



Source: Saunders, M.E. and Senkbeil, J.C. (2017), Perceptions of hurricane hazards in the mid-Atlantic region. Met. Apps, 24: 120-134. doi:10.1002/met.1611

Test with User Groups

Questions?

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